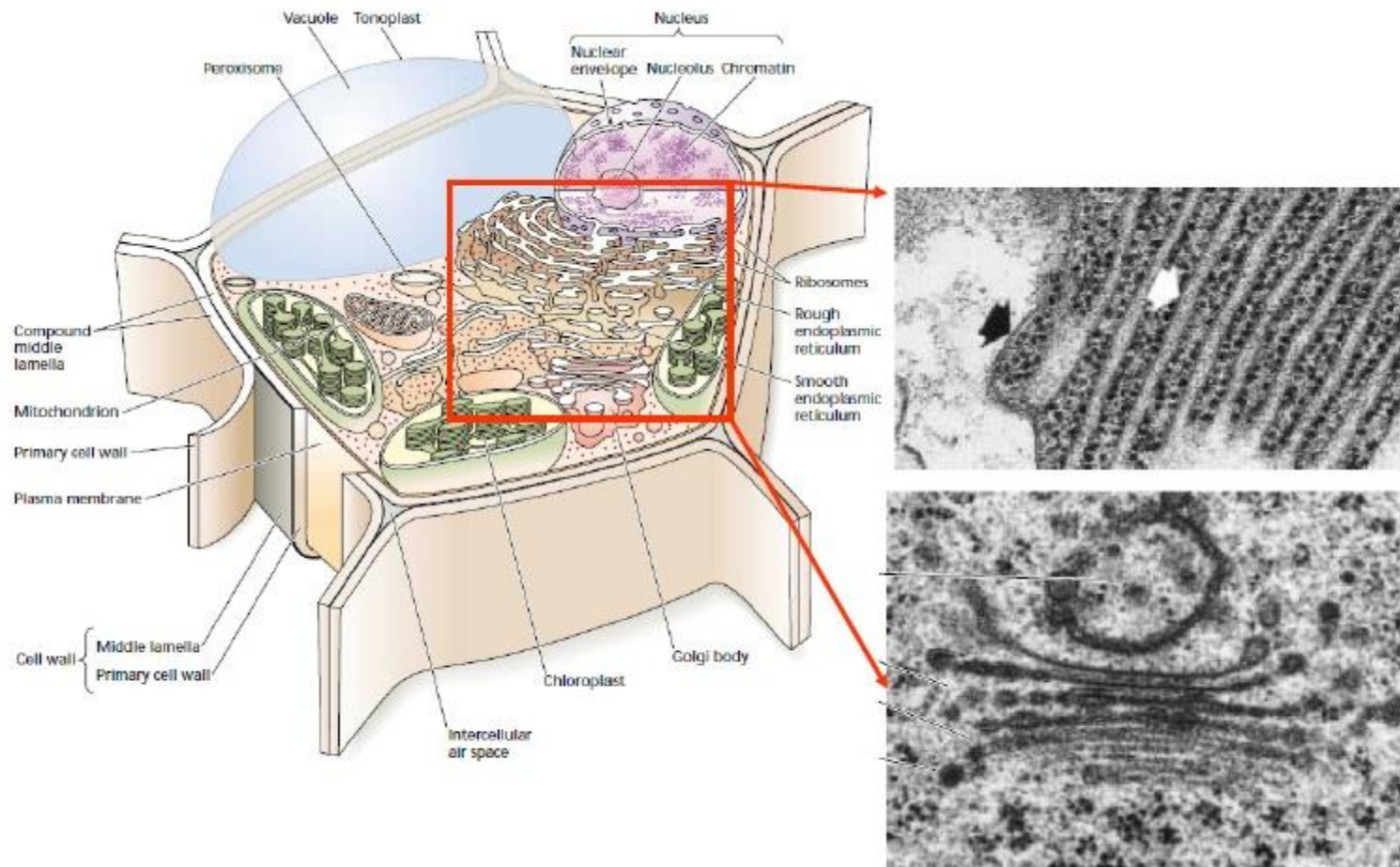
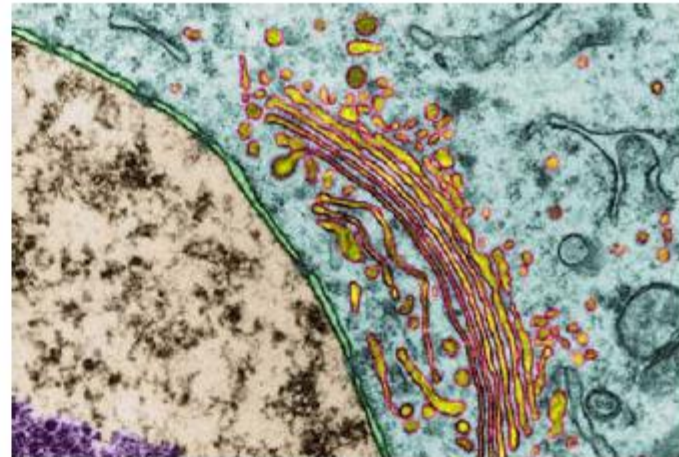
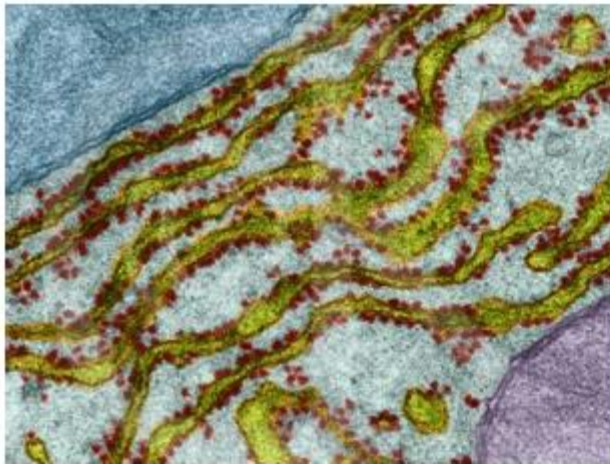


Endomembrane System



Endomembrane system

- Endoplasmic reticulum – smooth and rough
- Golgi apparatus
- Endomembrane system is very dynamic system: the same membrane may be once a part of nucleus, endoplasmic reticulum, Golgi apparatus, endosome, vacuole, lysosome or plasma membrane.
- Does include membranes of mitochondria and plastids.



ER

GA

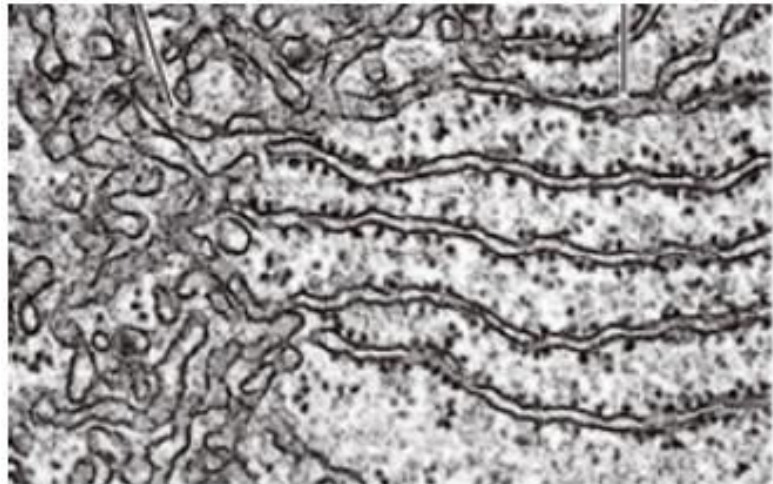
vacuole



Endoplasmic Reticulum (ER)

Endoplasmic reticulum

- Network of membranes forming cisternae, tubules and vesicles.
- Inside space – lumen.
- Rough endoplasmic reticulum – RER
- Smooth endoplasmic reticulum – SER
- Sarcoplasmic reticulum – SR



Ribosomes

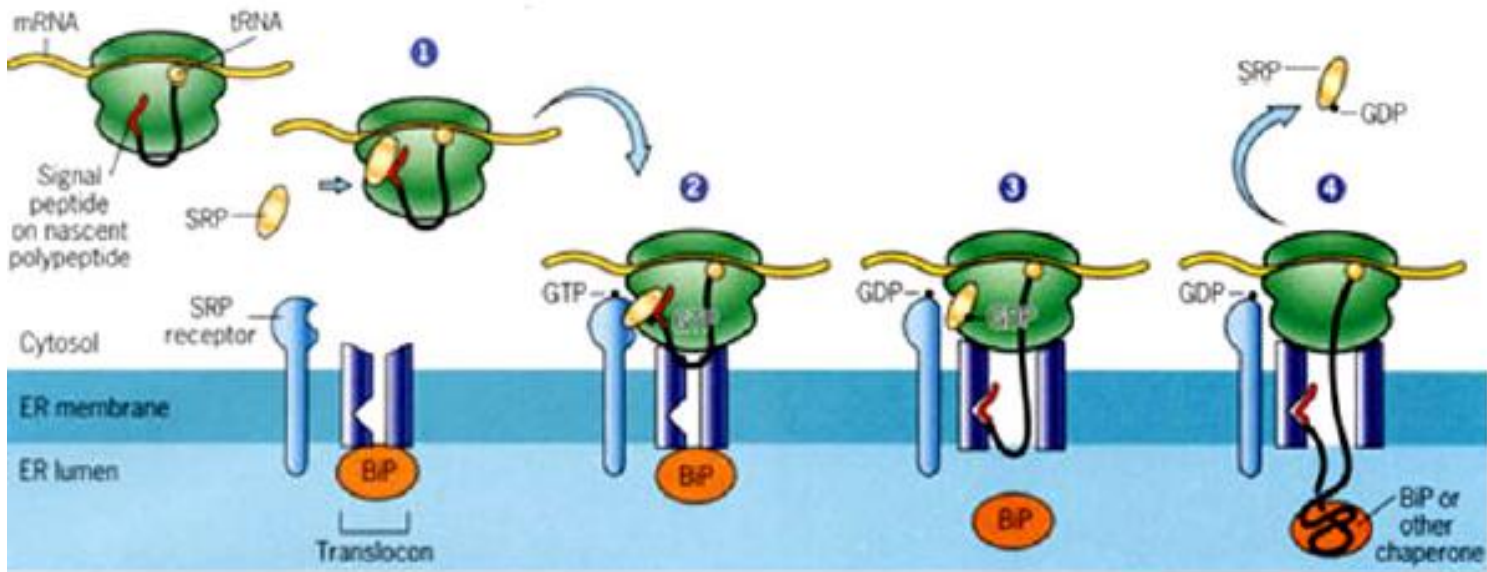
- 20 – 30 nm, formation in nucleolus
- Ensures translation of mRNA
- Consist of rRNA and proteins
- Prokaryotes, plastids, mitochondria – 70 S (in plastid stroma, in mitochondrial matrix) two subunits – 50 S (rRNA: 23 S, 5 S), 30 S (rRNA: 16 S)
- Eukaryotic cells – 80 S (free in the cytoplasm or associated to ER), two subunits 60 S (rRNA: 28 S, 5.8 S, 5 S), 40 S (rRNA: 18 S)
- Small subunit: binds mRNA
- Large subunit: catalytic functions (ribozyme, 23 S)
- Interaction with ER

Rough endoplasmic reticulum

- Membranes of endoplasmic reticulum associate with ribosomes, and thus proteosynthesis occurs.



Rough endoplasmic reticulum



- Co-translational translocation: nascent polypeptide contains at the beginning short sequence, which possesses like a signal for the peptide transport into the ER.
- This signal aminoacid sequence is recognised by SRP protein, that is binding to it. In ER membrane is present a SRP receptor – protein binding SRP.
- After the connection of SRP to SRP receptor the nascent polypeptide is translocated into the ER via a channel (translocon).

Rough endoplasmic reticulum

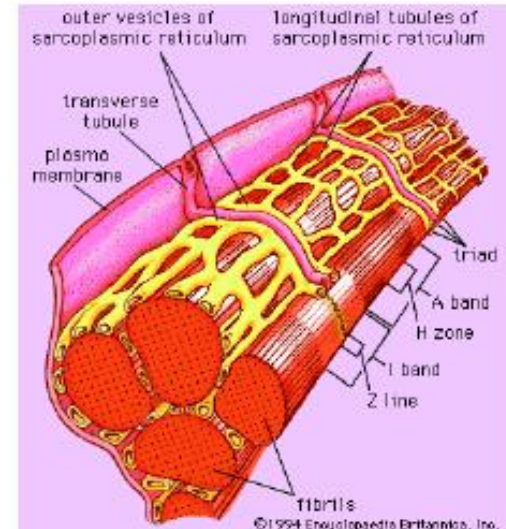
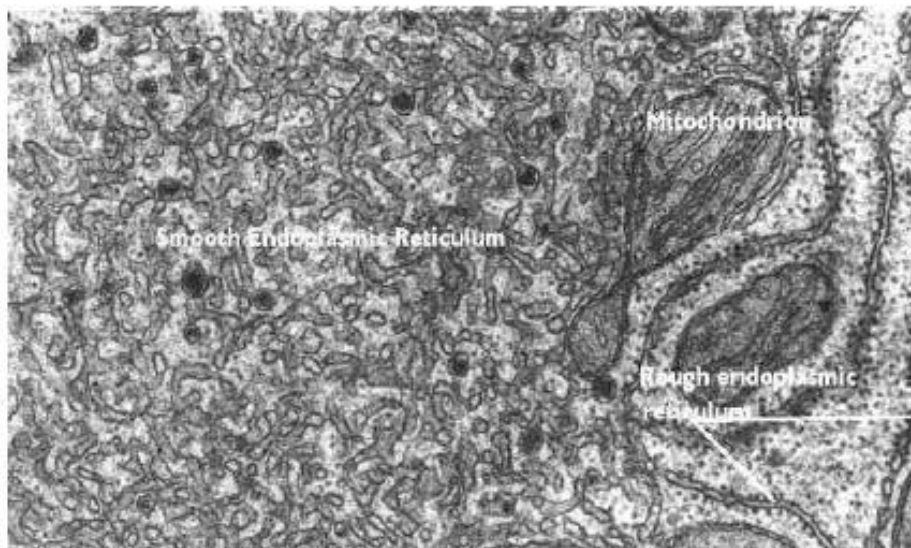
- In ER the synthesised proteins are modified:
- Proteins are folding into the correct shape (conformation) by chaperones
- In ER are control mechanisms avoiding of storage of incorrectly folded protein
- Many proteins are combined with saccharide chains (glycosylation). Glycosylated proteins are called glycoproteins.
- Covalent modification of proteins (phosphorylation, methylation, acetylation, formation of disulphidic bridges)
- Hydrolytic enzymes synthesis for lysosomes

Rough endoplasmic reticulum

- Proteins synthesised in ER and modified in ER lumen are often transported via vesicular transport into the Golgi apparatus and subsequently into vacuoles, lysosomes, peroxisomes, CM, or are secreted into the extracellular space via exocytosis (enzymes of digestive tract, serum proteins)
- The place of membrane formation, relation to the nuclear lamina, Golgi apparatus, plasmalemma, lytic compartment, vacuoles, protein bodies, peroxisomes).

Smooth endoplasmic reticulum

- Without ribosomes
- Importance in cell metabolism
- Synthesis of lipids, steroids (ovary cells), various enzymes
- Metabolism of sugars (glucose-6-phosphatase, glycogen metabolism)
- Regulation of Ca^{2+} concentration (sarcoplasmic reticulum)
- Detoxifying of toxic substances in liver cells
- Smooth and rough endoplasmic reticulum may fluently change regarding cell requirements

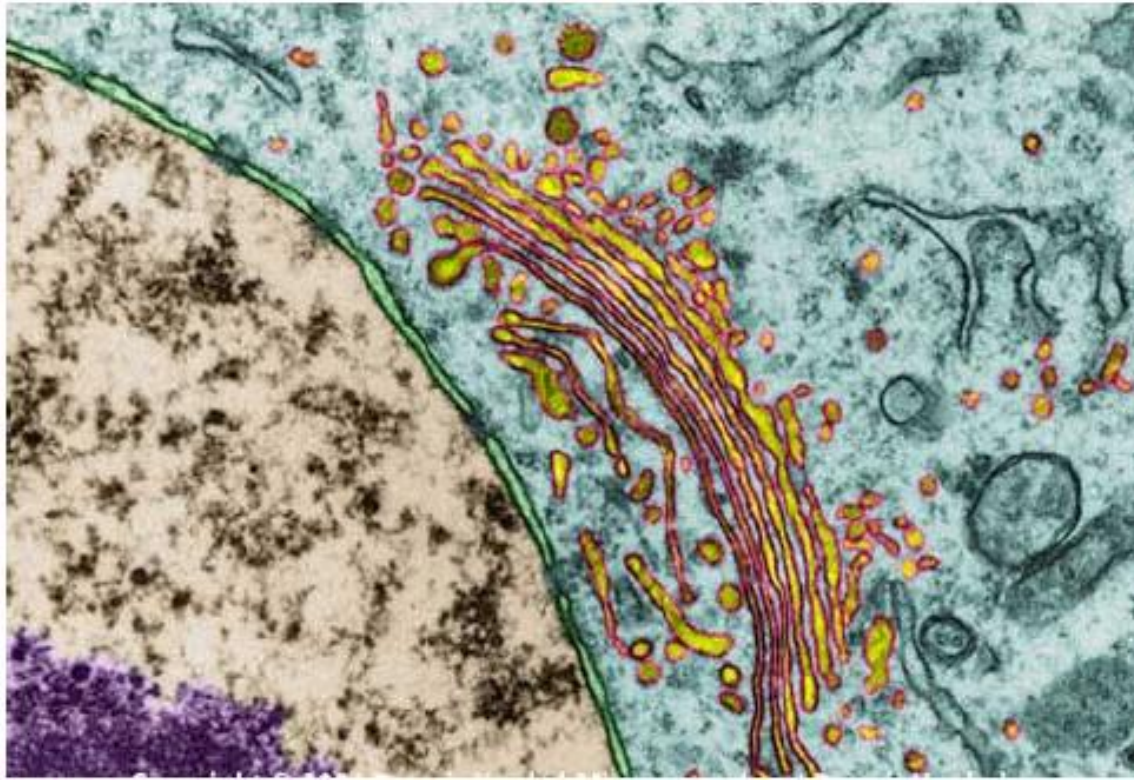


Golgi Apparatus

Golgi apparatus

Functions in the cells:

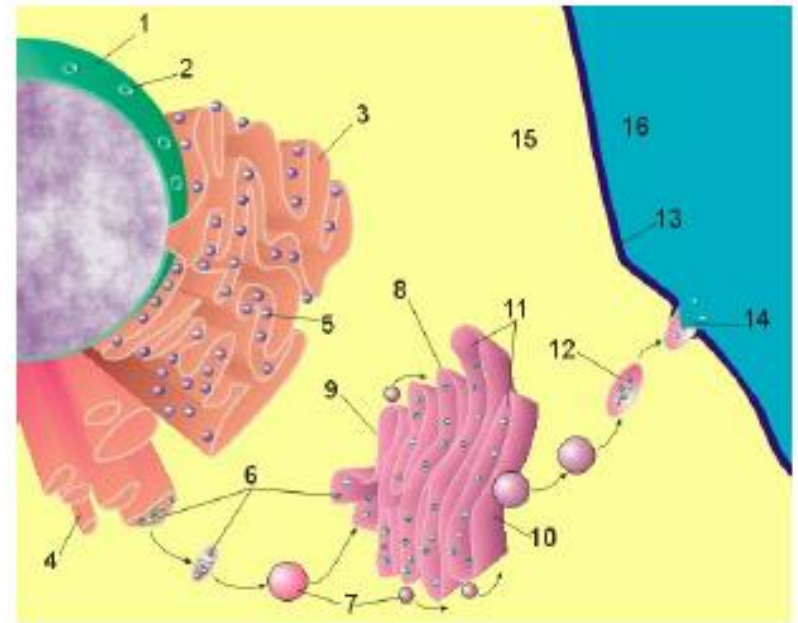
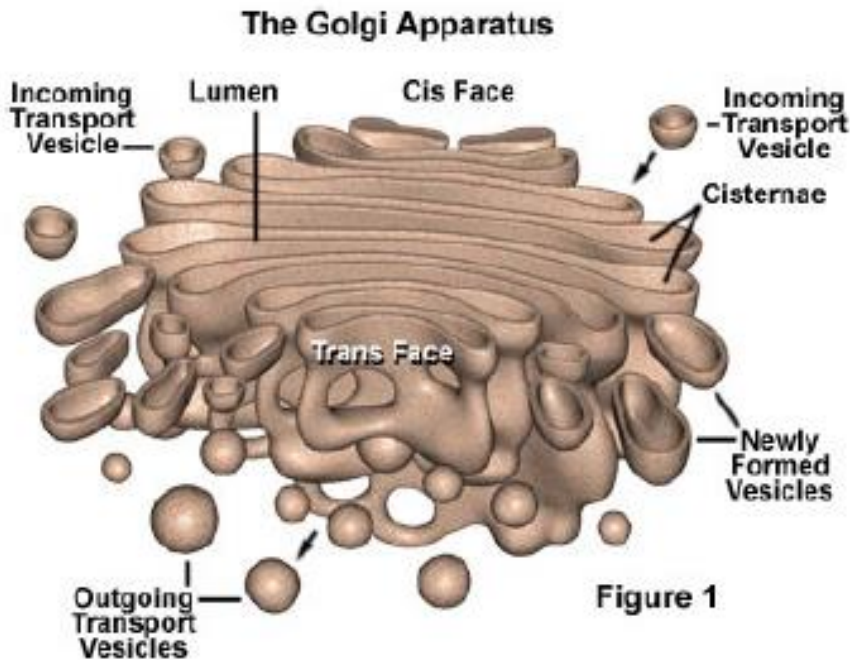
- Present in eukaryotic cells. Stacks are numerous in secretory cells.
- Important component of endomembrane system and consists of cisternae, tubules, and vesicles. They form specific shape – dictyosomes.
- GA is functionally interconnected to endoplasmic reticulum.



Golgi apparatus

Functions in the cells:

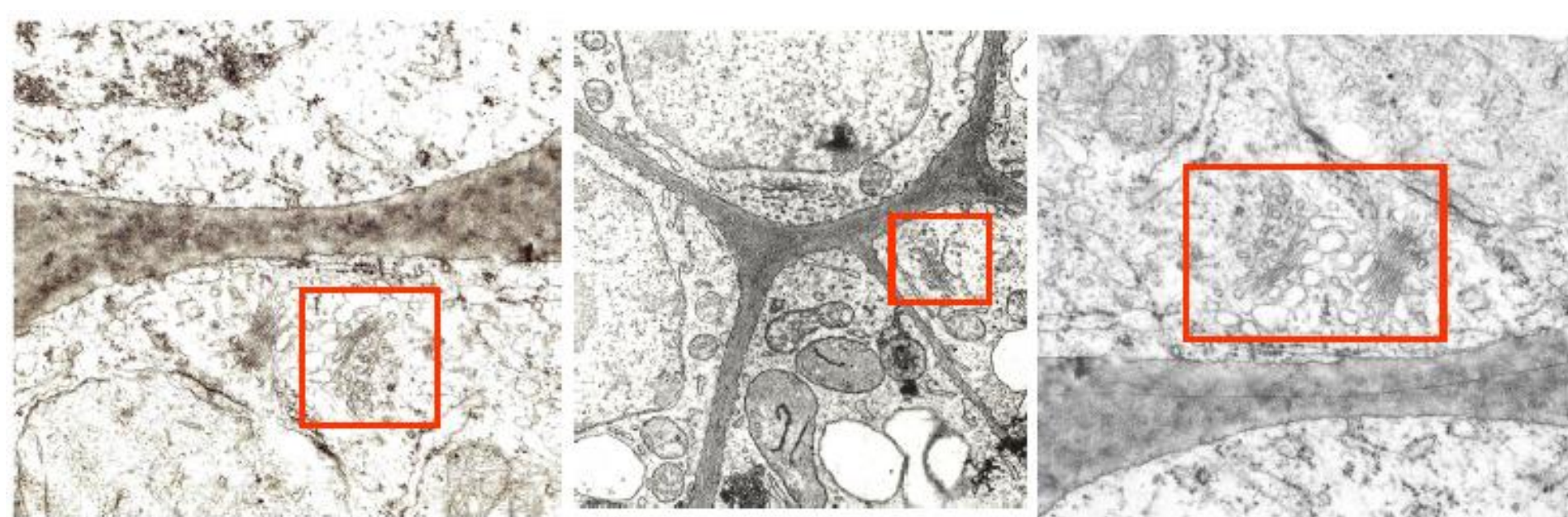
- Vesicles and cisternae of GA are located polarly.
- Vesicles leaving ER are directed to their targets, e.g. GA via specific proteins in membrane vesicles. Vesicles coming from ER fuse in cis pole of GA. Subsequently new cisternae of GA are formed, where modification of their material (medial GA). In trans pole of GA the vesicles with modified content are derived and transported to their targets (CM, lysosomes, vacuole, extracellular space, etc.)
- Transport and subsequent ER and GA vesicle fusion are not random!



Golgi apparatus

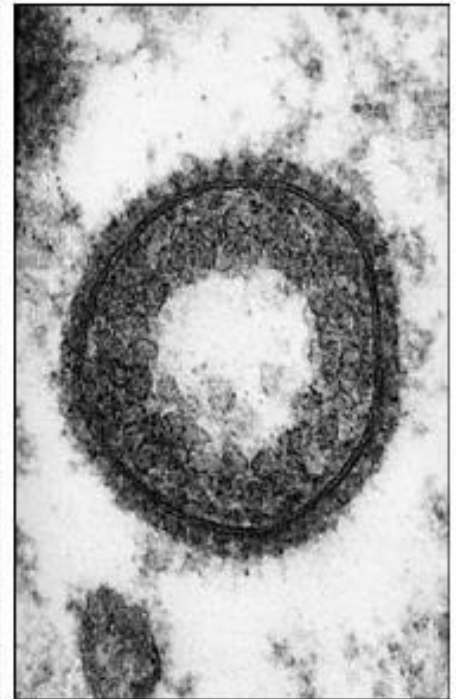
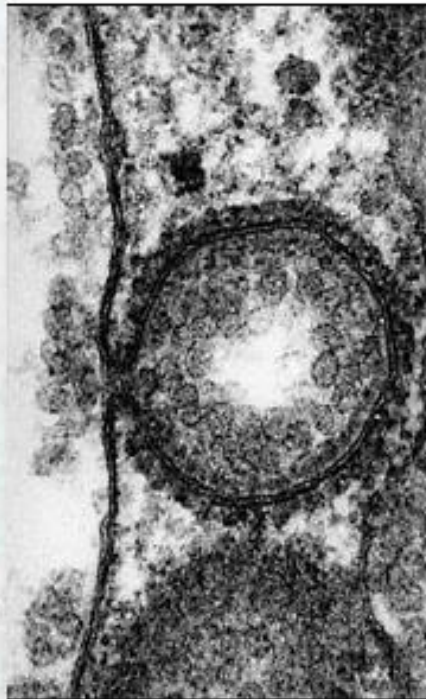
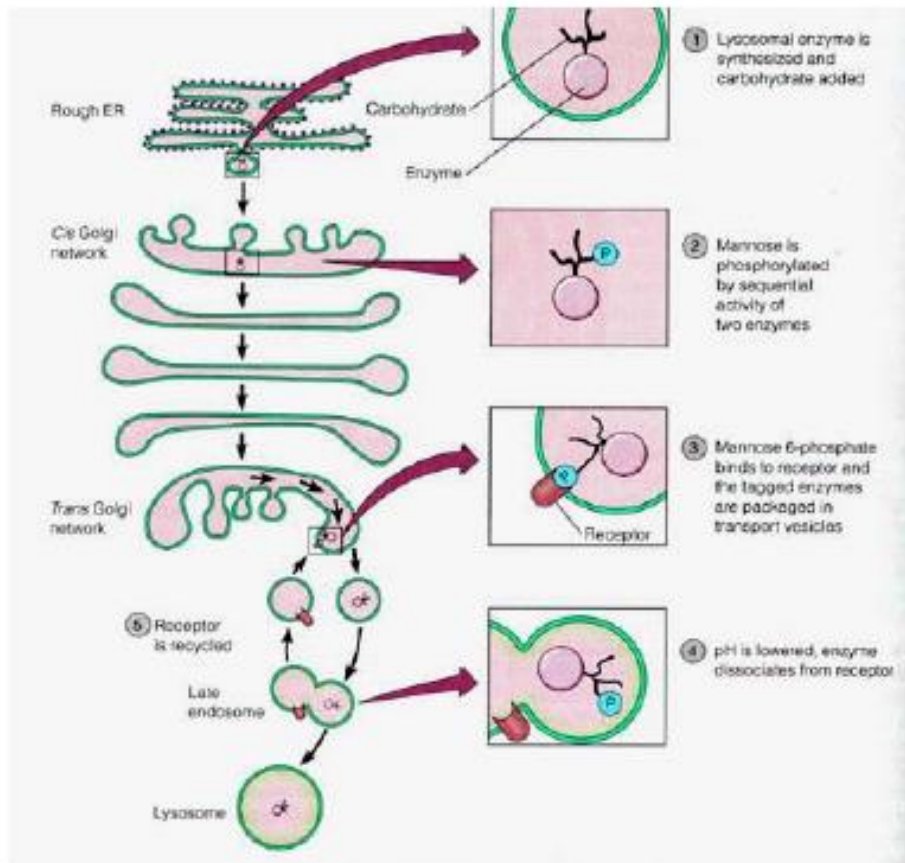
Functions in the cells:

- **Protein modifications** (coming from ER), e.g. modification of lysosome enzymes.
- **Concentration** of exported **material**.
- **Vesicular transport**.
- **Creation of glycoproteins**.
- **Secretion** of proteins, peptidoglycans, lipids, and other compounds (rich in secretory cells)
- **Biogenesis** of cytoplasmic membrane, cell wall (phragmoplast), lytic compartment, vacuoles – membrane flux.



Formation and transport of vesicles

- Two main issues: how to ensure a uniform content of transported vesicle and how to ensure its transport into the correct target?
- „Coat protein“ – cargo receptor, adaptin, dynamin, clathrin



0.1 μm

Formation and transport of vesicles

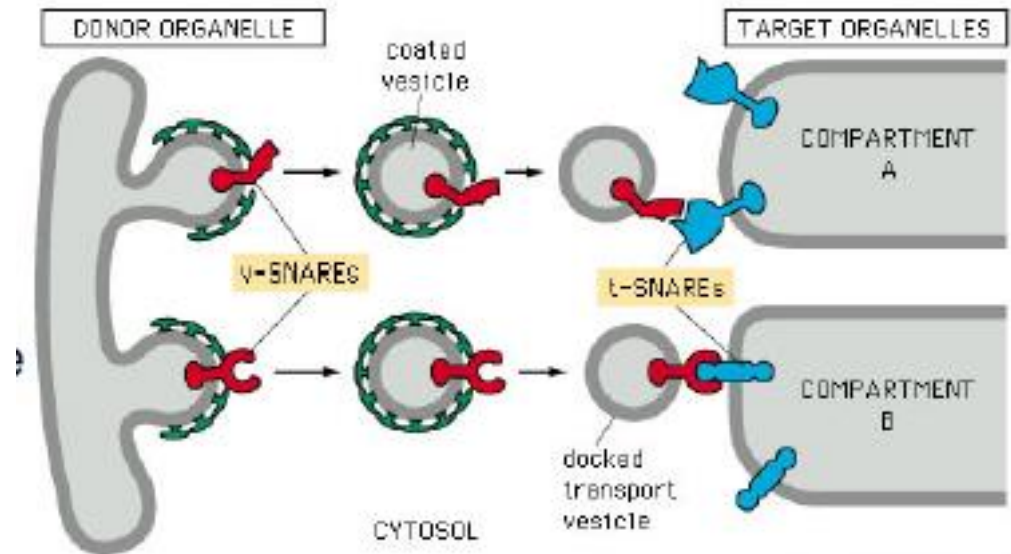
- **SNARE proteins:**

vSNARE (vesicle)

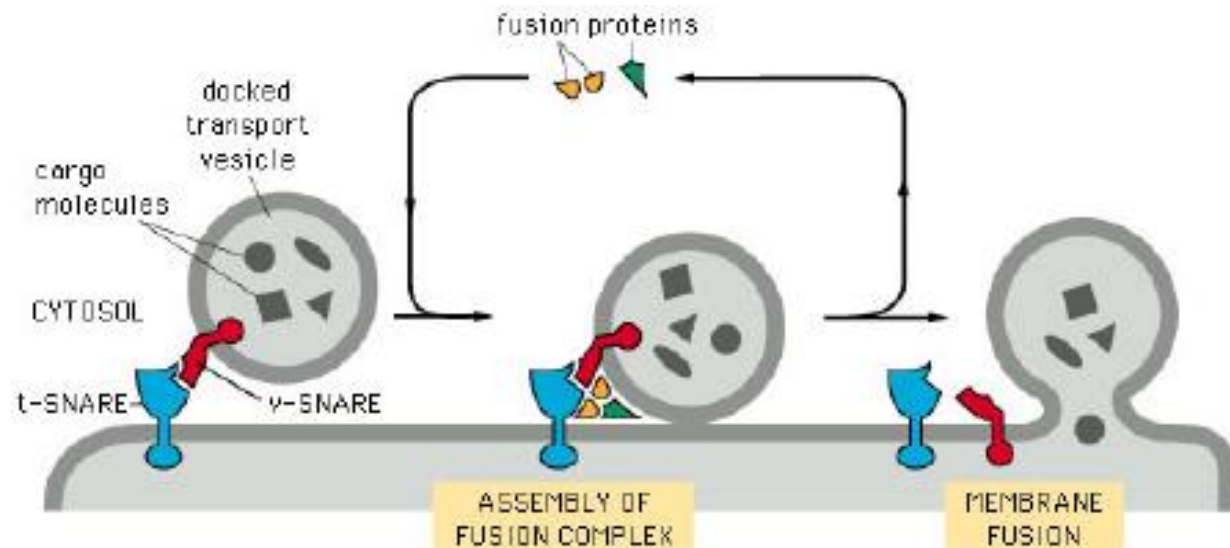
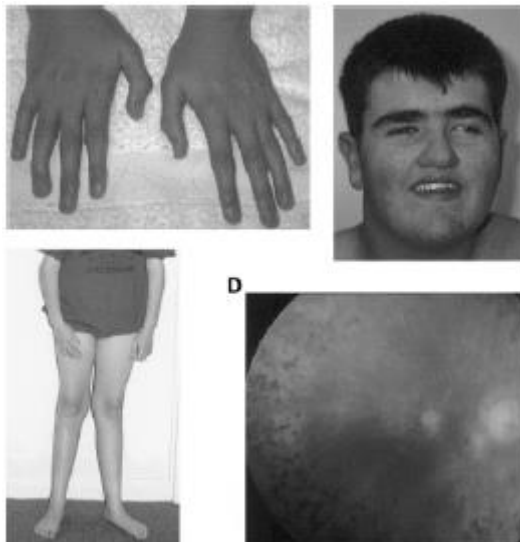
tSNARE (target)

- interaction of vSNARE and tSNARE ensures correct protein targeting

- mistakes in vesicle distribution may result in critical developmental malformations (Cohen syndrome)



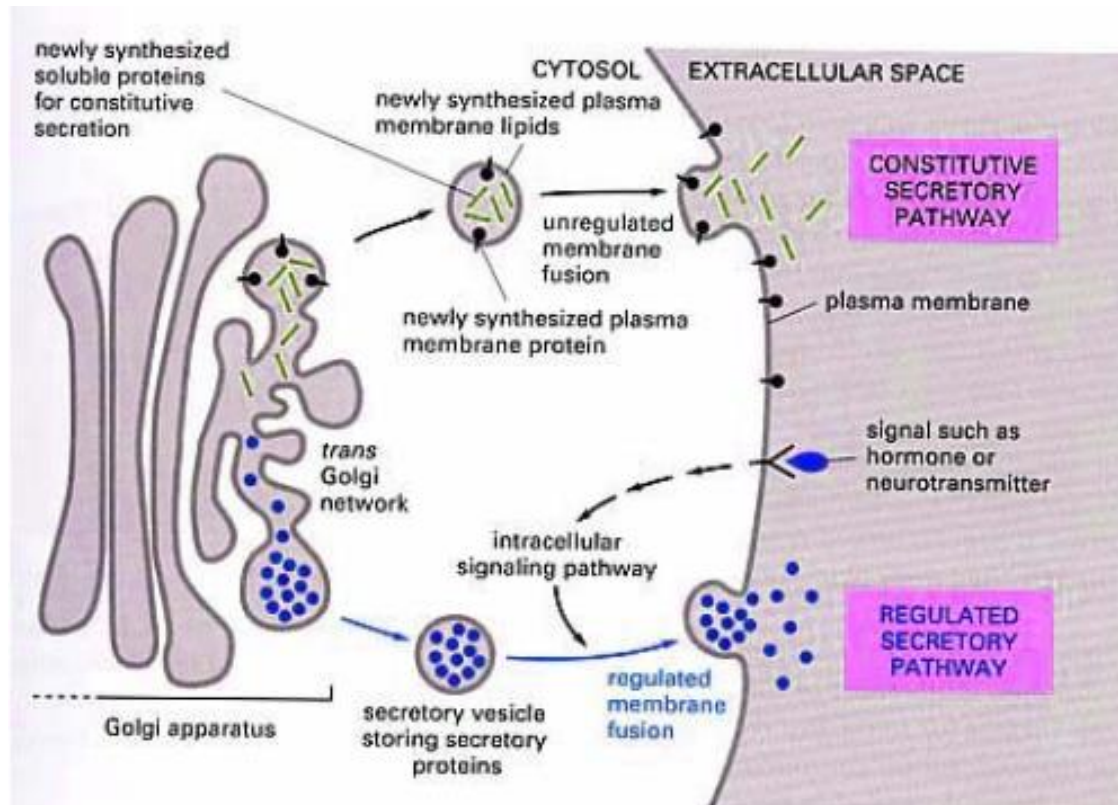
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Formation and transport of vesicles

- **Constitutive secretion** – a material is continuously secreted regardless of external factors or signals, usual vesicles, e.g. containing material of cell wall.
- **Regulated secretion** – not continuously, needs a activation signal or factor, e.g. beta cell of pancreas producing insulin.



Transport mechanisms

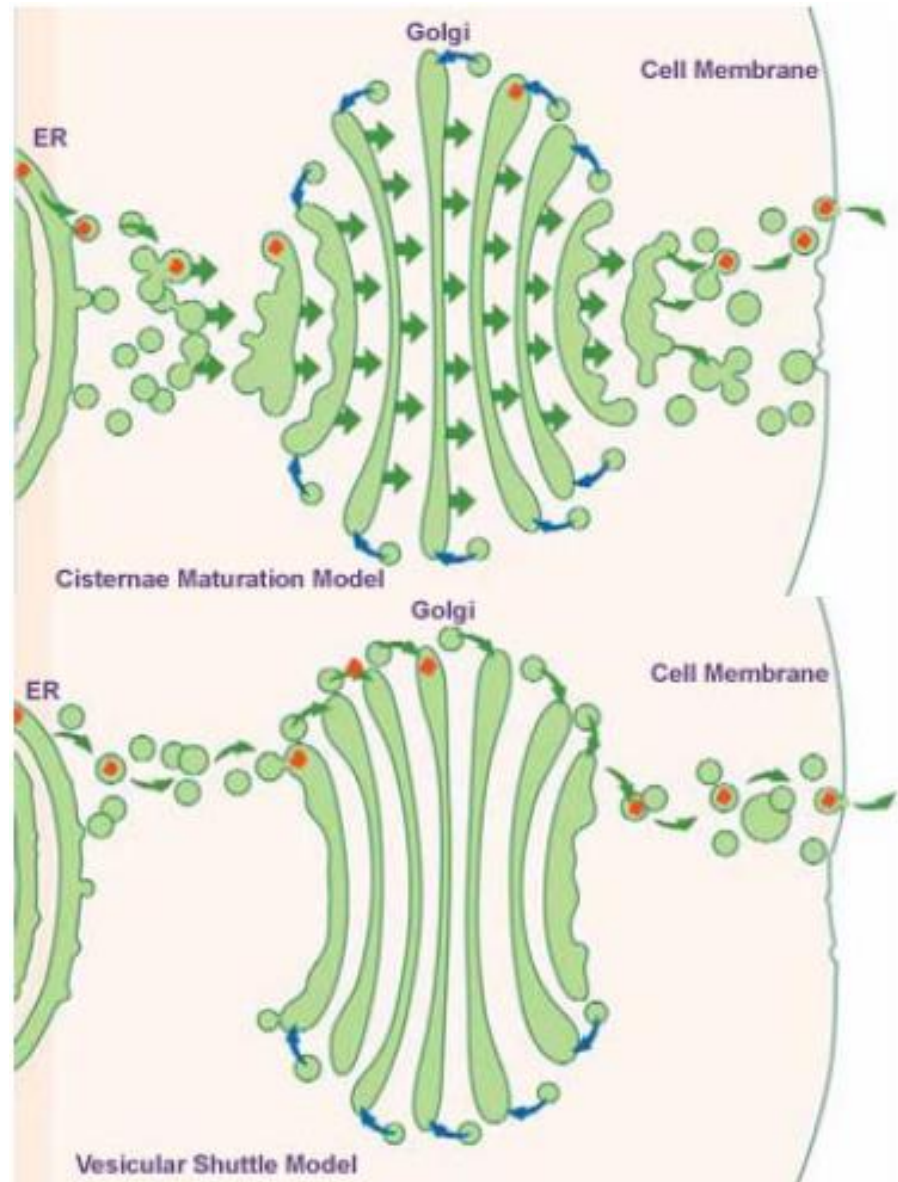
- **Cisternae maturation**

model: new cisternae form in *cis* side and finish in *trans* side. The cisterna automatically move if on *cis* side a new cisterna is formed.

- **Vesicular transport**

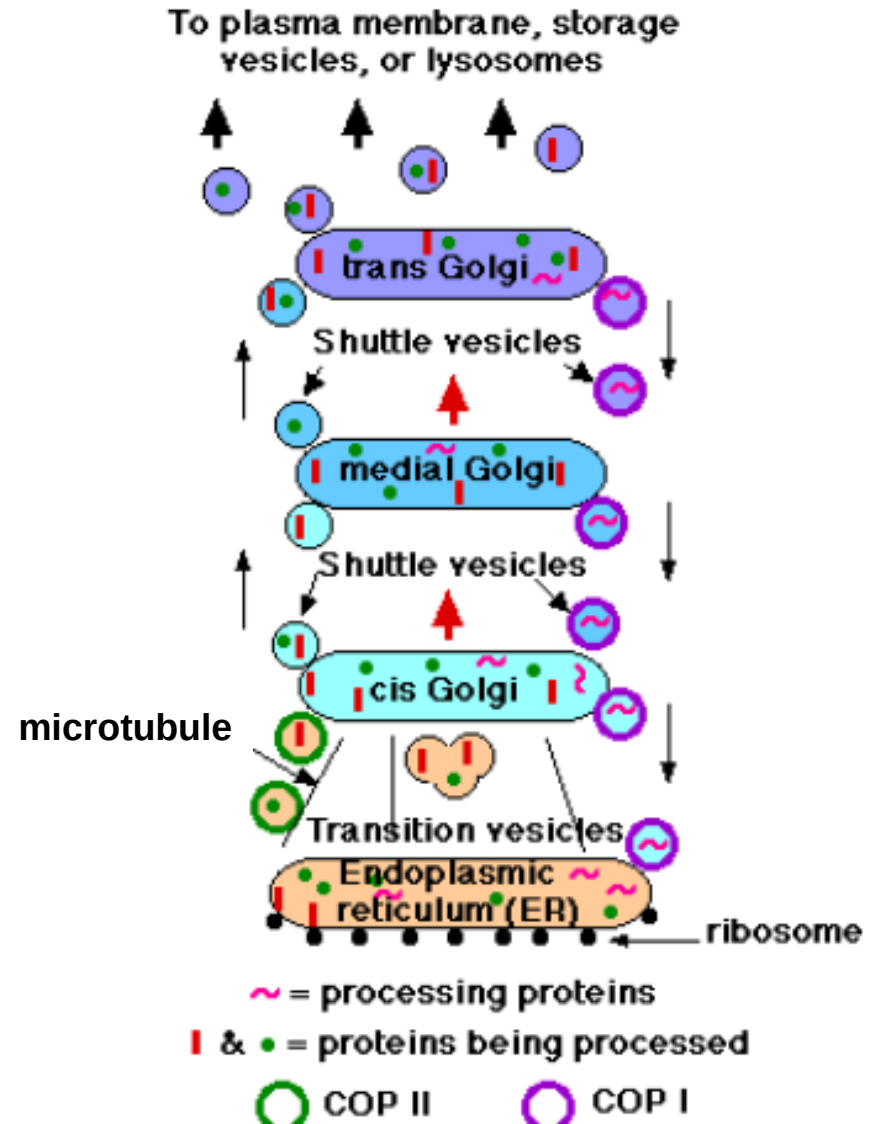
model: *cis* and *trans* sides are fixed, the material is transported via vesicles.

- Both models are valid!



Bi-directional transport of vesicles

- *Anterograde movement* – from *cis* to *trans* pole, dominant in secretion
- *cisternae maturation model*
- *Retrograde movement* – from *trans* to *cis* pole, e.g. receptor KDEL on endoplasmic reticulum
- *vesicular transport model*



Golgi apparatus is dynamic structure

